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marquardt AIRCRAFT CO.

Report No. PR 211-4

Enclosure (1)

(Unclassified Title)

LOW PRESSURE COMBUSTION INVESTIGATION

Contract No. NOas 59-0117

Marquardt Project No. 211

1 April 1959

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I. INTRODUCTION

This is the fourth monthly letter progress report on Navy Contract NOas 59-0117 (MAC Project 211) for the period 2 March to 2 April 1959.

The objectives of this program are:

a. to evaluate combustion performance of a 28-inch diameter ramjet engine operating at combustion pressures less than 6 psia for pentaborane, HiCal-3, SF-1, and hydrocarbon fuels

b. to evaluate the structural reliability of a full-scale nonmetallic tailpipe and exhaust nozzle

c. to determine the infrared radiation of the exhaust plume of a 28-inch ramjet engine operating at combustion pressures less than 6 psia with pentaborane, HiCal-3, SF-1, and hydrocarbon fuels.

II. PROGRAM PROGRESS

All the testing was completed on 12 March 1959 simulating the conditions required of inlet air temperatures approximating 700°F and combustion chamber pressures of 3 psia and under. The tests were run with emphasis on cruise-type operation. It meant operating the engine at lean fuel-air ratios in the region from 0.01 to 0.02.

The accomplishments of this test program were: (a) the attaining of combustion data on all the fuels called out in the objectives, (b) the evaluation of the structural reliability of a full-scale nonmetallic tailpipe and exhaust nozzle, and (c) the attaining of infrared radiation of the exhaust plume of the boronhydride-type fuel, SF-1, and hydrocarbon fuels.

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Insofar as combustion performance is concerned, the pentaborane and HiCal-3 fuels operated over a wide range and ignited with ease, indicating exceptional burning stability. SF-1 burned smoothly but did not ignite as easily as the boron-base fuels. The hydrocarbon fuel burned smoothly but did not burn as lean or ignite as readily as the other fuels. From preliminary data the combustion efficiency of pentaborane appeared to be 95% in a fuel-air ratio range of 0.008 to 0.015. The HiCal-3 fuel had a slightly lower efficiency indicating 90%, at a fuel-air ratio of 0.009, and dropping off at richer fuel-air ratios. With this fuel, the tailpipe length was varied from 60 in. to 126 in. with no major effect on combustion efficiency. The SF-1 fuel was evaluated for a fuel-air ratio range of 0.002 to 0.01. The tailpipe length was varied from 27 in. to 60 in. with a minor difference in performance indicated. From preliminary results at a fuel-air ratio of 0.006 combustion efficiency was approximately 80 to 85%. In evaluating the relative level of a hydrocarbon fuel, such as JP-4, to avoid minor hardware problems liquid and vaporized hexane were used. The vaporized fuel indicated the combustion efficiency of 95% and a fuel-air ratio range from 0.03 to 0.04. The performance of the liquid fuel was lower.

Although no reduced infrared data of the exhaust plumes are available at the present time, recordings were made of the infrared radiation from the exhaust of the HiCal-3, SF-1, and the hydrocarbon fuels.

The nonmetallic tailpipe was operated a total time of 2-1/2 hours. In the first 2 hours, it was operated at a material temperature of approximately 800°F. In the last half hour, in 10 minute increments, the temperature was increased so that by the time of fuel exhaustion the throat of the tailpipe had operated up to a temperature of 1150°F. On inspection of this tailpipe, there were no visual indications of deterioration at the exhaust nozzle throat where the maximum temperature occurred. However, some delamination occurred on the inner surface of the combustion chamber. There was no appearance of deterioration on the outer surface.

The work to be done consists of final data reduction of combustion efficiencies and infrared radiation from the plume and the preparation of the final report.

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III. PROBLEMS ENCOUNTERED

A. Unfortunately, problems of clogging of the fuel system occurred with the boronhydride fuels. The cause of clogging occurred due to contamination in the pentaborane shipping containers. Although the fuel was contaminated, the fuel had to be used because of a tight test schedule. However, it should be realized that the problem that occurred in the shipping container is not typical for this fuel.

B. The other problem that was encountered involved the multiplicity of hardware changes required to perform the many phases of the tests. Due to this, and the limited test time available, minor changes for optimizing the test hardware could not be made.

C. Due to failure of a fuel injector, some minor damage was done to the nonmetallic tailpipe. This resulted in a shortened tailpipe for the reliability tests.

IV. ESTIMATED COST TO DATE

The estimated cost, including all commitments, through 27 March 1959 is:

$86,900

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